

Marking, Enumeration, and Size Estimation for Coho and Chinook Salmon Smolt Releases into Upper Cook Inlet, Alaska in 1999

by

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Alaska Department of Fish and Game

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Weights and measures (metric)		General		Mathematics, statistics, fisheries	
centimeter	cm	All commonly accepted abbreviations.	e.g., Mr., Mrs., a.m., p.m., etc.	alternate hypothesis	H_A
deciliter	dL	All commonly accepted professional titles.	e.g., Dr., Ph.D., R.N., etc.	base of natural logarithm	e
gram	g	and	&	catch per unit effort	CPUE
hectare	ha	at	@	coefficient of variation	CV
kilogram	kg	Compass directions:		common test statistics	F, t, χ^2 , etc.
kilometer	km	east	E	confidence interval	C.I.
liter	L	north	N	correlation coefficient	R (multiple)
meter	m	south	S	correlation coefficient	r (simple)
metric ton	mt	west	W	covariance	cov
milliliter	ml	Copyright	©	degree (angular or temperature)	°
millimeter	mm	Corporate suffixes:		degrees of freedom	df
Weights and measures (English)		Company	Co.	divided by	÷ or / (in equations)
cubic feet per second	ft ³ /s	Corporation	Corp.	equals	=
foot	ft	Incorporated	Inc.	expected value	E
gallon	gal	Limited	Ltd.	fork length	FL
inch	in	et alii (and other people)	et al.	greater than	>
mile	mi	et cetera (and so forth)	etc.	greater than or equal to	≥
ounce	oz	exempli gratia (for example)	e.g.,	harvest per unit effort	HPUE
pound	lb	id est (that is)	i.e.,	less than	<
quart	qt	latitude or longitude	lat. or long.	less than or equal to	≤
yard	yd	monetary symbols (U.S.)	\$, ¢	logarithm (natural)	ln
Spell out acre and ton.		months (tables and figures): first three letters	Jan,...,Dec	logarithm (base 10)	log
Time and temperature		number (before a number)	# (e.g., #10)	logarithm (specify base)	log ₂ , etc.
day	d	pounds (after a number)	# (e.g., 10#)	mid-eye-to-fork	MEF
degrees Celsius	°C	registered trademark	®	minute (angular)	'
degrees Fahrenheit	°F	trademark	™	multiplied by	x
hour (spell out for 24-hour clock)	h	United States (adjective)	U.S.	not significant	NS
minute	min	United States of America (noun)	USA	null hypothesis	H_0
second	s	U.S. state and District of Columbia abbreviations	use two-letter abbreviations (e.g., AK, DC)	percent	%
Spell out year, month, and week.				probability	P
Physics and chemistry				probability of a type I error (rejection of the null hypothesis when true)	α
all atomic symbols				probability of a type II error (acceptance of the null hypothesis when false)	β
alternating current	AC			second (angular)	"
ampere	A			standard deviation	SD
calorie	cal			standard error	SE
direct current	DC			standard length	SL
hertz	Hz			total length	TL
horsepower	hp			variance	Var
hydrogen ion activity	pH				
parts per million	ppm				
parts per thousand	ppt, ‰				
volts	V				
watts	W				

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ABSTRACT

Approximately 575,000 coho salmon *Oncorhynchus kisutch* and 954,000 chinook salmon *O. tshawytscha* smolt were released at 11 locations in Cook Inlet and Prince William Sound in 1999. Of these, about 195,000 coho salmon and 520,000 chinook salmon were marked with an adipose finclip and a coded wire tag. Tag retention for individual release groups ranged from 93.9% to 99.3%. Fort Richardson Hatchery achieved the production goal of 80% of coho salmon smolt within the 15.1 g to 25.0 g size range for the Bird Creek release group. Fort Richardson also achieved the production goal of 80% of the chinook salmon smolt within the 5.1 g to 15.0 g size range for the Deception Creek release group. None of the remaining coho or chinook salmon release groups at Fort Richardson Hatchery or Elmendorf Hatchery achieved the production goal.

Mark-recapture population estimates were used for determining the number of fish in rearing units containing coho and chinook salmon at Elmendorf Hatchery. At Fort Richardson Hatchery an electronic counter was used to determine the number of fish in each rearing unit containing coho salmon, and a physical count obtained at the time of tagging was the reported number of fish released for each release group of chinook salmon.

Key words: hatchery, marking, coded wire tags, chinook salmon, *Oncorhynchus tshawytscha*, coho salmon, *Oncorhynchus kisutch*, mark-recapture, tag retention, size composition.

INTRODUCTION

Over half of Alaskans live in Southcentral Alaska, which receives the vast majority of the state's sport fishing effort. Hatchery-reared chinook salmon *Oncorhynchus tshawytscha* and coho salmon *O. kisutch* smolt have been stocked in numerous locations throughout Southcentral Alaska to improve or create terminal sport fisheries and relieve pressure on wild stocks (Appendix A). A critical element of most coho and chinook salmon hatchery smolt stocking projects in Cook Inlet and Prince William Sound is the use of coded wire tags (CWT) to mark these smolt. CWTs are used to estimate the contribution from individual stockings to commercial fisheries, marine and freshwater recreational fisheries, and personal use fisheries. Straying of stocked coho and chinook salmon is also evaluated using CWTs.

The accuracy of contribution estimates from mark recoveries is highly dependent upon the accuracy of the estimated number of unmarked fish in the release population. At Fort Richardson Hatchery (FRH) hatchery personnel used an electronic counter to determine the number of fish in each release group of coho salmon, and a physical count for the number of chinook salmon in each release group. At Elmendorf Hatchery (EH) we used mark-recapture experiments to estimate the number of fish in each release group.

Another important element of hatchery smolt stocking programs is the size of the fish. Mean size and the size distribution at release are indicators of the quality of hatchery smolt (Peltz and Starkey 1993). If smolt are too small at release, ocean survival will be poor; if smolt are too large at release, ocean residence will be reduced, shifting age composition of returns to younger, smaller fish (Sweet and Peltz 1994). Weight distributions determined for each rearing unit at release allow hatchery personnel to determine the quality of smolt being released.

The specific objectives for this project were:

1. To estimate the number of coho and chinook salmon smolt reared at EH using mark-recapture techniques;
2. To estimate the weight composition of each release group;

3. To estimate the long-term (>30 days) tag retention rate of each group of marked fish.

The goal of this project was to mark with an adipose clip and CWT approximately 690,000 of the projected 2,115,000 coho and chinook smolt to be stocked in 1999. This entailed marking a representative sample of at least 20,000 coho salmon from one release group, and at least 40,000 coho or chinook salmon smolt from each of the remaining 12 release groups.

This report presents the results of the 1999 marking program. Based on the data summarized in this report, recommendations are made for future marking and collection of release data. All data for this report are held and archived by Policy and Technical Services, Sport Fish Division, Alaska Department of Fish and Game.

METHODS

SMOLT MARKING

Elmendorf Hatchery raised coho salmon from Bear Lake brood stock, and chinook salmon from Ship Creek and Homer (Crooked Creek) brood stocks. Fort Richardson Hatchery raised coho salmon from Ship Creek (Little Susitna River) and Jim Creek brood stocks, and chinook salmon from Deception Creek and Ninilchik River brood stocks (Table 1). Fish from 13 release groups were released at eight different sites in Cook Inlet and three different sites in Prince William Sound (Fleming Spit, Valdez Glacier Stream, and Shakespeare Creek). Each release group was marked with a unique tag code (Tables 2 and 3).

We used a systematic sampling procedure to obtain a representative sample of smolt for marking from each release group where only a portion of the fish was to be tagged. For each rearing unit of coho salmon at FRH, technicians crowded fish to one end of the raceway, dipnetted all the fish and placed approximately every third dip net of fish into net pens to be held for tagging. These fish were held separate from the rest of the population until they were tagged. All of the smolt in the Ninilchik River and Deception Creek chinook salmon smolt release groups were marked and tagged. Approximately 90% of the smolt in each of the three Prince William Sound release groups were marked and tagged. After the tagging was complete and tagged fish were placed into raceways, the remaining unmarked fish for the Prince William Sound release groups were hand counted into the raceways.

At EH fish were selected for tagging when a raceway was split. In the splitting process, technicians crowded and held the fish at one end of the original raceway. All fish that were to be transferred to a new raceway were dip netted, weighed, and either placed in net pens to be held for tagging, or released in the new raceway. Approximately every third to fifth dip net of fish was held for tagging, depending on the estimated proportion to be tagged. Fish remaining in the original raceway were also netted, weighed, and then either placed into net pens for tagging or returned to the raceway on the other side of the crowder. After all fish in the raceway were weighed, the crowder was removed. All fish in the net pens were marked and tagged. If fish for a particular release group were in more than one raceway, then an attempt was made to mark approximately the same proportion of fish in each raceway (Peltz and Miller 1990).

Table 1.-Total release, number of fish marked with adipose clips and coded wire tags stocked into various systems in Cook Inlet and Prince William Sound in 1999, and the number of fish examined to achieve the desired level of precision.

Stocking Site	Brood Stock	Number of Fish in Raceway	Inventory Method Used	Number of Raceways	Number Marked per Raceway	Average Examined per Raceway per Experiment	Number M-R ^a Experiments	Precision
<u>Elmendorf Hatchery</u>								
<u>Coho Salmon</u>								
Homer Spit	Bear Lake	67,587	mark-recapture	2	22,654	2,690	1	+/-5
		62,015	mark-recapture		21,751	3,004	1	+/-5
<u>Chinook Salmon</u>								
Crooked Creek	Homer (Crooked Creek)	99,681	mark-recapture	2	21,735	5,383	1	+/-5
		93576	mark-recapture		21,872	4,551	1	+/-5
Ship Creek	Ship Creek	110,358	mark-recapture	2	21,738	5,304	1	+/-5
		86,810	mark-recapture		22,527	3,891	1	+/-5
Homer Spit Early	Homer (Crooked Creek)	106,783	mark-recapture	2	21,681	5,451	1	+/-5
		56,387	mark-recapture		20,880	2,370	1	+/-5
<u>Fort Richardson Hatchery</u>								
<u>Coho Salmon</u>								
Campbell Creek	Ship Cr (Little Susitna River)	42,046	electronic count	1	20,879	NIA	NIA	
Bud Creek	Ship Cr (Little Susitna River)	111,430	electronic count	1	37,344	NIA	N/A	
Eklutna Tailrace	Jim Creek	126,602	electronic count	1	44,073	NIA	NIA	
Ship Creek	Ship Cr (Little Susitna River)	93,224	electronic count	2	26,257	NIA	NIA	
		72,164	electronic count		22,042			
<u>Chinook Salmon</u>								
Deception Creek	Deception Creek	201,586	physical count	1	201,586	NIA	NIA	
Ninilchik River	Ninilchik River	49,853	physical count	1	49,853	NIA	NIA	
Fleming Spit	Deception Creek	49,773	physical count	1	45,705	NIA	NIA	
Valdez Glacier Stream	Deception Creek	49,353	physical count	1	46,528	N/A	NIA	
Shakespeare Creek	Deception Creek	49,797	physical count	1	45,023	NIA	NIA	
Totals		1,529,025			714,128			

^a M-R is mark-recapture.

Table 2.-Summary of coded wire tagging data and release estimates at Elmendorf and Fort Richardson hatcheries for coho salmon smolt stocked at five locations in Cook Inlet in 1999.

Parameter	Fort Richardson ^a				Elmendorf ^b	Totals
	Campbell Creek E2	Bird Creek E3	Eklutna Tailrace E4	Ship Creek F3 & F4 ^c	Homer Spit RW4 & 5	
Tag Codes	31-01-30	31-26-15	31-26-16	31-26-14 31-01-29	31-01-40	
Total marked and tagged	20,942	37,533	44,261	68,156	44,587	215,479
Mortalities	63	189	188	19,857	182	
Marked fish released	20,879	37,344	44,073	48,299	44,405	195,000
Tag retention sample size	764	774	757	1,559	1,523	
Tag retention at release	97.60%	98.40%	96.80%	93.90%	96.90%	96.50%
Tag retention variance	3.02E-05	1.97E-05	4.06E-05	3.82E-05	1.97E-05	
Tagged fish released	20,378	36,746	42,663	45,380	43,020	188,188
Tagged fish variance	13,144	27,537	78,876	89,042	38,747	
Total fish released	42,046	111,430	126,602	165,388	129,602	575,068
Percent marked	49.70%	33.50%	34.80%	29.20%	34.30%	33.90%
Tagging dates	11/06/1998 11/10/1998	11/10/1998 11/16/1998	10/20/1998 10/27/1998	10/27/1998 11/02/1998	01/19/1998 01/26/1998	
Date of tag retention check	05/26/1999	05/20/1999	05/19/1999	05/11/1999	05/20/1999	
Days elapsed	197	185	204	194	119	

^a Total fish released is **an** electronic count.

^b Total fish released is **a** mark-recapture estimate.

^c The marked fish released for the Ship Creek release group is **an** estimate based on a marked-to-unmarked ratio obtained prior to release.

Table 3.-Summary of coded wire tagging data and release estimates at Elmendorf and Fort Richardson hatcheries for chinook salmon smolt stocked at five locations in Cook Inlet and three locations in Prince William Sound in 1999.

Parameter	Fort Richardson Hatchery ^a					Elmendorf Hatchery ^b			Totals
	Deception Creek D1	Ninilchik River Head D3	Fleming Spit Tail D3	Valdez Glacier Stream Tail D2	Shake-speare Creek Head D2	Crooked Creek RW7 & RW18	Ship Cr. RW8 & RW16	Homer Early Run RW15 & RW17	
Tag Codes	31-26-17, 18,19,20 31-01-31	31-01-45	31-26-23	31-26-22	31-26-24	31-01-41	31-01-42	31-01-45	
Total marked and tagged	202,166	50,167	45,922	46,656	45,218	43,982	44,644	42,877	521,632
Mortalities	580	314	217	128	195	375	379	316	
Marked fish released	201,586	49,853	45,705	46,528	45,023	43,607	44,265	42,561	519,128
Tag retention sample size	764	799	759	757	755	1,515	1,530	1,558	
Tag retention at release	99.10%	98.10%	99.30%	98.70%	97.50%	98.20%	95.50%	95.00%	98.10%
Tag retention variance	1.19E-05	2.31E-05	8.63E-06	1.72E-05	3.25E-05	1.16E-05	2.82E-05	3.05E-05	
Tagged fish released	199,772	48,906	45,385	45,923	43,897	42,844	42,262	40,423	509,413
Tagged fish variance	483,508	57,371	18,035	37,328	65,953	21,985	55,186	55,329	
Total fish released	201,586	49,853	49,773	49,353	49,797	193,257	197,168	163,170	953,957
%marked	100.00%	100.00%	91.80%	94.30%	90.40%	22.60%	22.50%	26.10%	54.40%
Tagging dates	02/17/1999 03/18/1999	04/08/1999 04/15/1999	03/18/1999 03/24/1999	03/24/1999 04/01/1999	04/01/1999 04/07/1999	01/29/1999 02/04/1999	02/08/1999 02/12/1999	01/26/1999 01/29/1999	
Date of tag retention check	06/11/1999	06/10/1999	06/10/1999	06/10/1999	06/11/1999	06/02/1999	05/24/1999	06/01/1999	
Days elapsed	85	56	78	70	65	118	105	126	

^a Total fish released from Fort Richardson Hatchery is a physical count.

^b Total fish released from Elmendorf Hatchery is based on a mark-recapture estimate.

All fish were tagged with a full-length CWT (1.1 mm) using a Northwest Marine Technology' Mark IV tag injector. All of the marked smolt from release groups in 1999 were graded and tagged using the appropriate size head mold. At least 510 fish were obtained from each stock up to 7 days before the start of tagging. Each fish was measured for fork length to the nearest millimeter, and a length frequency distribution was calculated. The two or three head mold sizes that cumulatively fit at least 80% of the fish length distribution were selected for tagging, and the fish were graded accordingly.

Fish that were to be marked were anesthetized with MS-222. The adipose fin was excised at the base using surgical scissors. Tags were then injected into the noses of the fish, and the fish were sent through a Quality Control Device (QCD). The QCD detected the magnetized tag and separated the fish with tags **from** those without tags. All fish without tags were tagged again. Quality control checks for tag placement were conducted following initial daily startup, and following a change in head mold size or a change in tagging personnel. During each quality control check, a minimum of two tagged fish were dissected to determine tag placement (Moberly et al. 1977; Figure 1). Head mold or wire adjustments were made when necessary. The fish that were killed to determine tag placement were subtracted from the daily number of tagged fish and were not included **as** tagged fish.

After tagging, all fish were held in net pens overnight to determine short-term mortality and estimate short-term tag retention rate. All overnight mortalities were counted and recorded. Short-term retention rates were estimated daily by passing a random sample of 200 fish through the QCD. If the physical retention rate was at least 85%, this level of sampling would have provided an estimate that was within 5 percentage points of the true retention rate 95% of the time (Cochran 1977). Daily tag retention rate (\hat{D}_i) of smolt that were finclipped, tagged, survived, and retained the tag was estimated **as** a binomial proportion:

$$\hat{D}_i = \frac{n_i}{n_{ti}}, \quad (1)$$

where:

n_i = number of live smolt in the sample tagged on day i that retained the tag, and
 n_{ti} = total number of live smolt in the sample tagged on day i,

and a variance of:

$$\text{Var}(\hat{D}_i) = \frac{\hat{D}_i(1 - \hat{D}_i)}{n_{ti} - 1}. \quad (2)$$

Tagged smolt were combined with untagged smolt following overnight mortality checks, and all fish were treated the same until release. Fish mortality in each raceway was monitored daily and all marked and unmarked mortalities were recorded.

¹ Use of a company's name does not constitute endorsement.

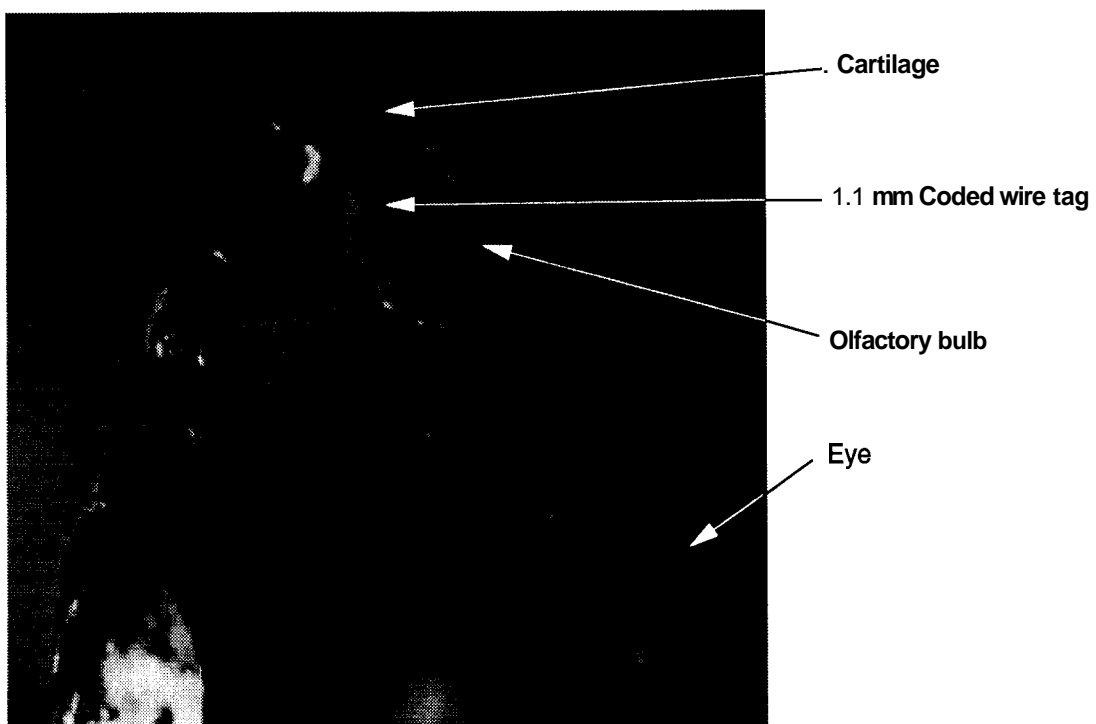
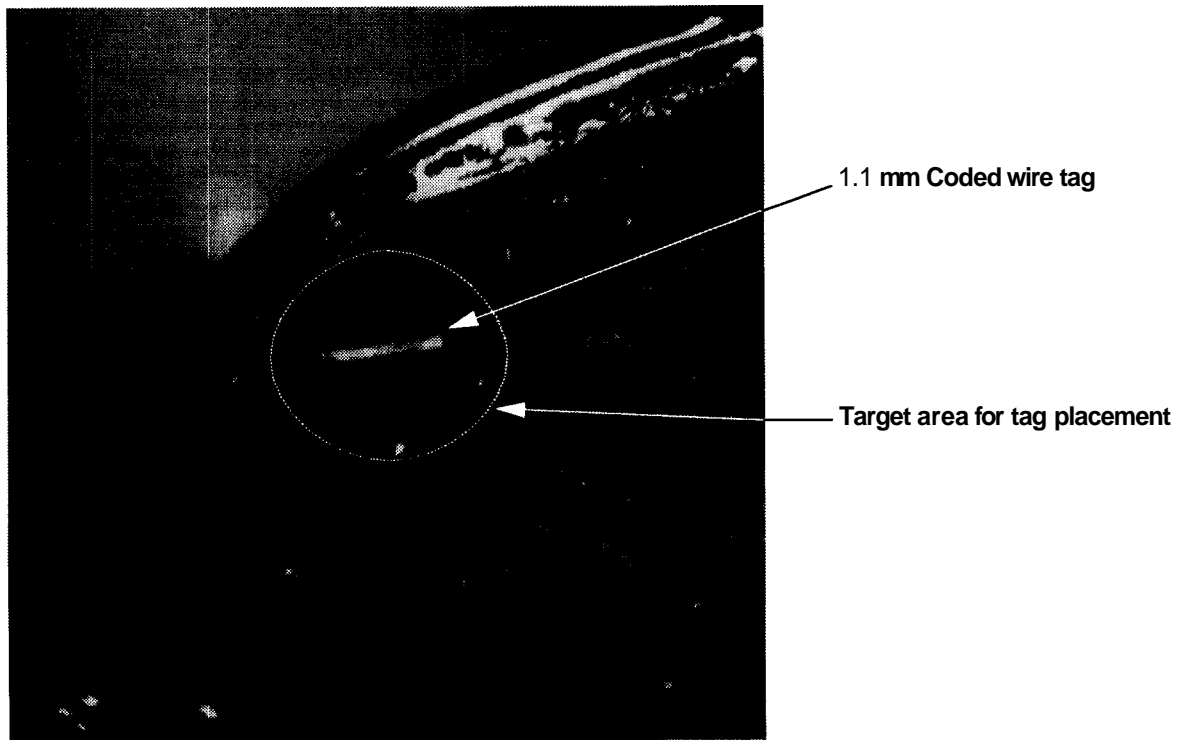


Figure 1.-Proper placement of a coded wire tag in a small fish.

Long-term tag retention was estimated for all release groups at least 30 days after tagging (Blankenship 1990). Fish were crowded in each rearing container, then at least 750 marked fish (adipose clipped) were randomly sampled from the population and checked for tag retention using a hand held CWT detector. If the physical retention rate was at least 75%, this level of sampling would have provided an estimate that is within 2.5 percentage points of the true retention rate 97.5% of the time (Cochran 1977). Long-term tag retention rate (D_j) of smolt that were finclipped, tagged, survived, **and** retained the tag, and its variance, were also estimated **as** a binomial proportion (equations 1 and 2) for each group,

where:

n_i = number of tagged smolt in the sample that retained the tag; and

n_{ti} = total number of tagged smolt in the sample.

The number of fish released with valid CWTs was estimated **as**:

$$\hat{T}_j = (N_j - M_j) \hat{D}_j, \quad (3)$$

and its variance **as**:

$$\text{Var}(\hat{T}_j) = (N_j - M_j)^2 \text{Var}(\hat{D}_j), \quad (4)$$

where:

N_j = number of fish injected with a tag in group j ,

\hat{D}_j = long-term tag retention of release group j , and

M_j = total number of mortalities of tagged fish in group j .

SMOLT ENUMERATION

Using an electronic fish counter, hatchery personnel determined the number of smolt in five rearing units of coho salmon at FRH. During the tagging season **as** fish were injected with tags, tagging personnel obtained a physical count of chinook salmon in the five rearing units at FRH. Prior to release, we estimated the number of smolt in all groups released from EH with the mark-recapture technique.

Physical Counts

Physical counts at FRH for chinook salmon smolt stocked at Ninilchik River, Deception Creek, Fleming Spit, Shakespeare Creek, and Valdez Glacier Stream were established upon completion of tagging. All of the fish in the Ninilchik River and Deception Creek release groups were tagged. Approximately 45,000 fish in each of the three Prince William Sound release groups were tagged. All tagged fish are counted during the tagging process. Approximately 5,000 unmarked fish were hand counted into each of the Prince William Sound release groups at the completion of tagging. Mortalities were monitored on a daily basis and subtracted from the original count to yield a final physical count for each release group.

Mark-Recapture Estimates

Each release group contained a known number of fish marked **with** an adipose clip **and** a CWT. These marked fish were used in mark-recapture experiments to estimate the number of fish in

each of the eight raceways at EH. A random sample of fish from these raceways was examined for marks prior to release and the number of marked and unmarked fish was recorded.

Given the number of marked fish per raceway, and using formulas from Robson and Regier (1964), the number of fish per raceway that needed to be examined for marks in order to obtain the desired level of precision was calculated (Table 1).

The number of fish in each raceway was estimated using Chapman's modification of the Petersen estimate (Seber 1982). The estimate of abundance at the time of release was calculated as:

$$\hat{N} = \frac{(n_1 + 1)(n_2 + 1)}{m_2 + 1} - 1; \quad (5)$$

with variance:

$$\text{Var}(\hat{N}) = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2(m_2 + 2)},$$

where:

- n_1 = the number of fish marked with an adipose finclip and CWT in each raceway,
- n_2 = the number of fish examined for marks in each raceway during the second sampling event, and
- m_2 = the number of marked fish observed in each raceway during the second sampling event.

This two-sample mark-recapture model assumes:

1. The population is closed, with no additions, and losses are known between sampling events;
2. All fish have an equal probability of capture during the marking event or during the second sampling event, or marked fish mix completely with unmarked fish prior to the second sampling event;
3. Marking does not affect the probability of capture during the second sampling event;
4. Marks are not lost between sampling events; and
5. Marked fish observed during the second sampling event are correctly identified and recorded.

There were no additions to any raceway and all mortalities between events were known. Personnel obtained fish through systematic sampling during the marking event, and took fish from a crowded population of fish in the raceway during the second sampling event, thus attempting to minimize violating the second assumption.

Size Estimation

A minimum of 510 fish were individually measured for length and weight from each rearing unit for each release group at both EH and FRH. Fish were crowded to one end of the raceway and a sample was netted and put into a small holding pen. Each fish was measured to the nearest

millimeter using an electronic fish measuring board, and weighed to the nearest 0.1 gram on an electronic scale. Mean weight and the associated variances of fish in each release group were estimated using standard normal procedures.

RESULTS

SMOLT MARKING

The tagging crew marked 195,000 coho salmon and 519,128 chinook salmon smolt for release at eight locations in Cook Inlet and three in Prince William Sound in 1999 (Table 1). Tagging goals were achieved for 12 of 13 release groups. Hatchery personnel underestimated the population size of the Bird Creek release group, and not enough fish were systematically removed prior to tagging. Only 37,344 of the anticipated goal of 40,000 fish were marked.

Long-term tag retention was checked **56** days to 204 days after tagging (Tables 2 and 3). Tag retention for the release groups ranged from 93.9% to 99.3% with an overall mean of 96.5% for coho salmon and 98.1% for chinook salmon. Approximately 575,000 coho salmon and 954,000 chinook salmon smolt were released. The percentage of the total release that was marked per release group ranged from 22.5% to 100% (Tables 2 and 3).

SMOLT ENUMERATION

One mark-recapture estimate with confidence intervals was made for each of eight raceways at EH (Table 4). The estimates are reported as total fish released in Tables 2 and 3.

The fish in each of the five rearing units of coho salmon at FRH were counted electronically using VAKI bioscanners. These counts were reported as the total fish released for each of these release groups (Table 2).

Physical counts were obtained at the time of tagging on all five chinook salmon release groups reared at FRH (Table 3).

Table 4.-Mark-recapture estimates for eight rearing units of coho and chinook salmon smolt released from Elmendorf Hatchery into three release sites in Cook Inlet in 1999.

	Coho		Chinook					
	Homer Spit RW4	Homer Spit RW5	Crooked Creek RW7	Crooked Creek RW18	Ship Creek RW8	Ship Creek RW16	Homer Early Run RW15	Homer Early Run RW17
Estimate	67,587	62,015	99,681	93,576	110,358	86,810	106,783	56,387
SE	1,797	1,501	2,501	2,448	2,983	2,296	2,790	1,477
Upper 95% CI	71,109	64,956	104,583	98,375	116,206	91,310	112,251	59,282
Lower 95% CI	64,065	59,074	94,779	88,777	104,511	82,309	101,315	53,492

SIZE ESTIMATION

Weight frequency distribution of coho and chinook salmon smolt are presented in Table 5 and Figures 2 and 3. At FRH **only** the Bird Creek coho salmon release group achieved the production goal where 80% of the fish were between 15.1 and 25.0 g. The Deception Creek chinook salmon release group achieved the production goal where 80% of the fish were between 5.1 and 15.0 g. Smolt weight was below the suggested production goal for most coho salmon release groups and above the suggested goal for chinook salmon release groups. At EH none of the release groups achieved the suggested production goal. All release groups had smolt that were above the desired size range.

Table 5.-The percentage of coho and chinook salmon released from Elmendorf and Fort Richardson hatcheries in 1999 that are within the desired size range, smaller than the desired size range, and larger than the desired size range.

Hatchery	Percent		
	Within	Below	Above
Coho: preferred range 15.1 - 25.0 grams			
Elmendorf Hatchery	30.7%	2.7%	66.5%
Fort Richardson Hatchery	72.9%	19.0%	8.2%
Chinook: preferred range 5.1 - 15 grams			
Elmendorf Hatchery	35.4%	0.0%	64.6%
Fort Richardson Hatchery	78.4%	0.0%	21.6%

DISCUSSION

SMOLT MARKING

A major point of emphasis for the marking program has been to achieve good long-term tag retention rates. Overall retention levels have remained steady at greater than 97% over the past five tagging seasons. The combined long-term tag retention for chinook and coho salmon in 1999 was 97.7% (Tables 2 and 3). We feel that grading fish and using different sizes of head molds for tagging is responsible for maintaining acceptable long-term tag retention rates. Poor quality control contributed to a lower than normal long-term tag retention rate for coho salmon tagged at FRH and released into Ship Creek.

SMOLT ENUMERATION

The physical counts and mark-recapture estimates were conducted without incident in 1999.

This ~~was~~ the first year hatchery personnel have used the VAKI electronic fish counters. During the counting process personnel manually counted small groups of electronically counted fish to

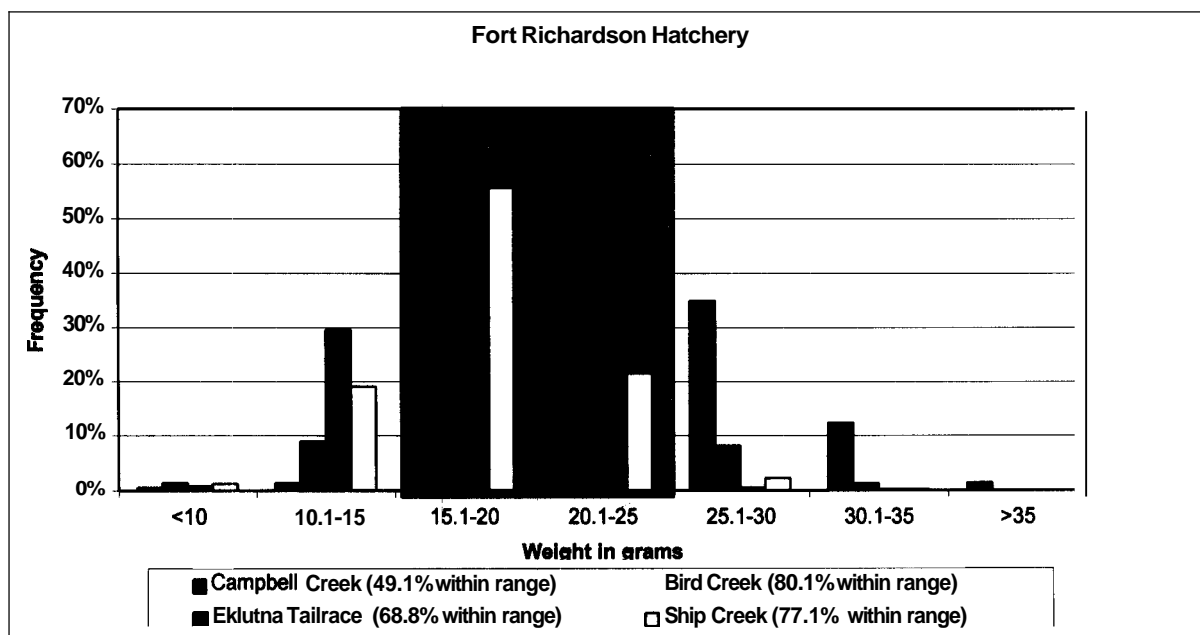
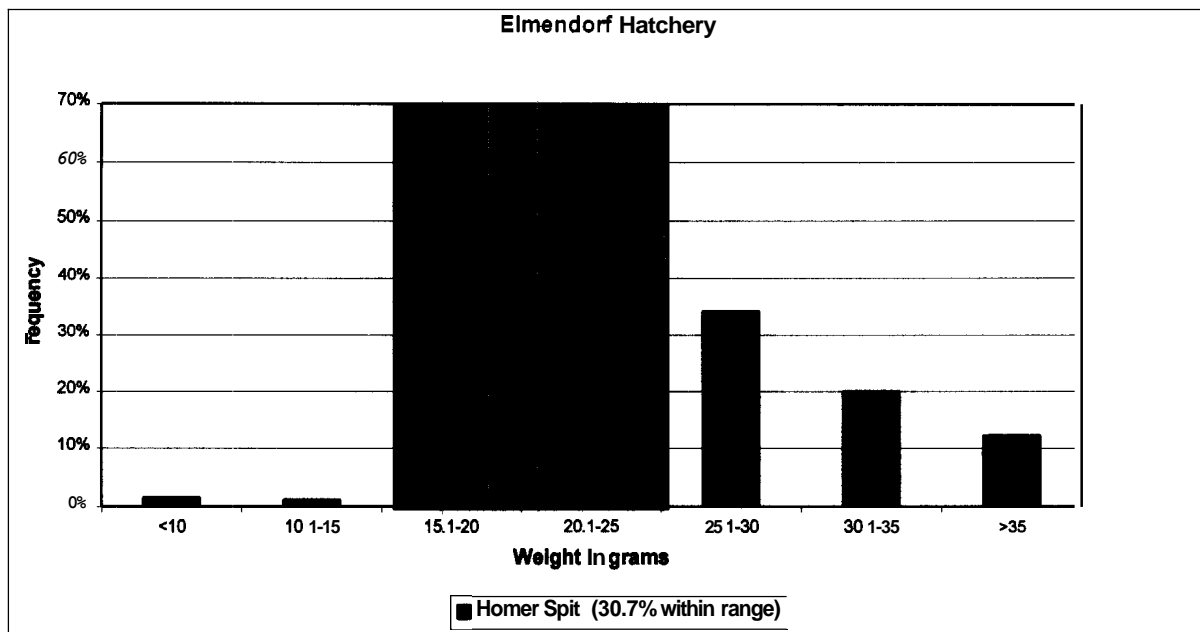


Figure 2.-Weight distributions and ideal weight range for coho salmon reared at Elmendorf and Fort Richardson hatcheries and released in 1999.

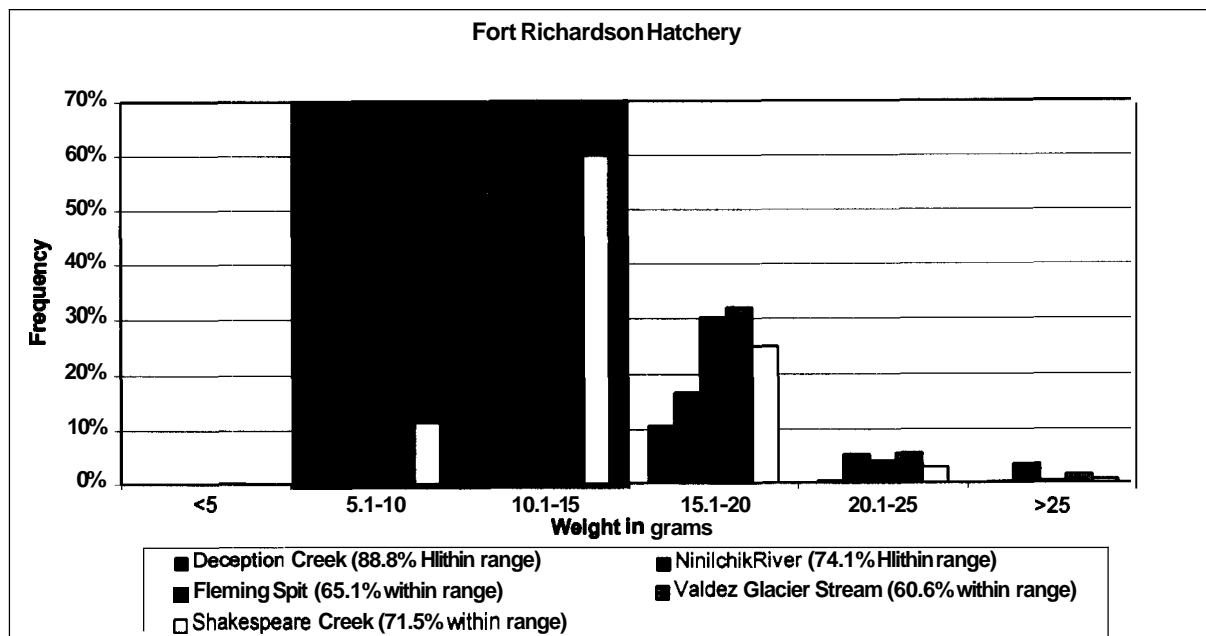
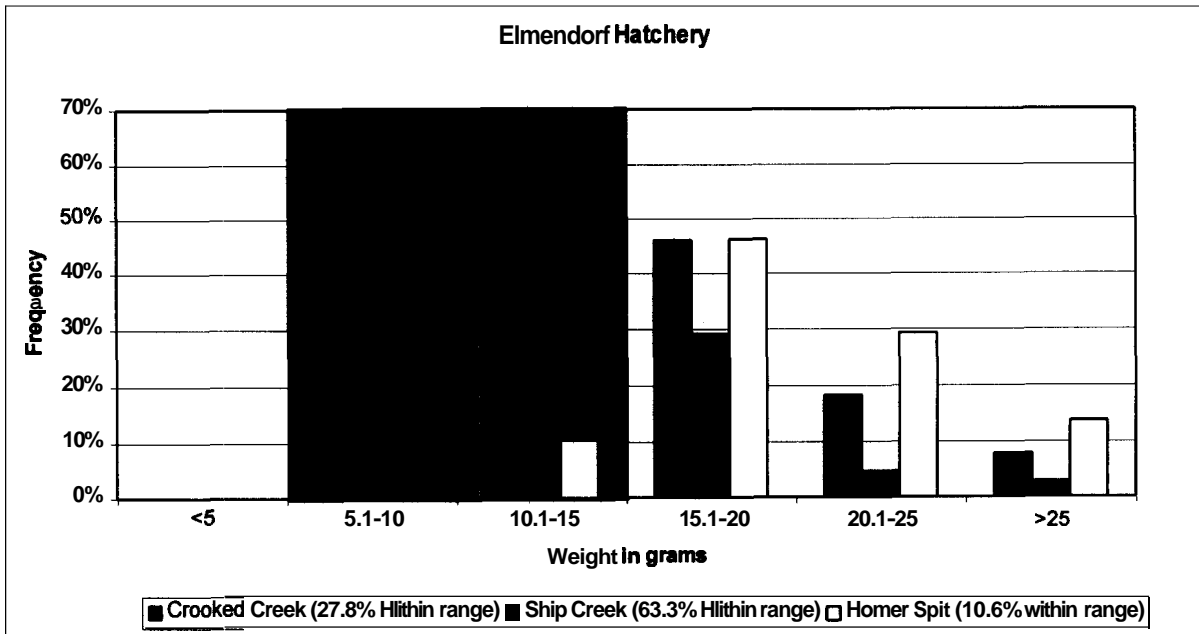


Figure 3.-Weight distributions and ideal weight range for chinook salmon reared at Elmendorf and Fort Richardson hatcheries and released in 1999.

verify the accuracy of the electronic counters. By moving the fish through the bioscanners slowly and consistently, hatchery personnel are confident in the accuracy of the VAKI electronic fish counters that were used to count the number of fish in each rearing unit of coho salmon at FRH.

Approximately **70,000** coho salmon smolt destined for Ship Creek died when a pump failed at FRH. Because of the large number of smolt involved and the urgency in removing them, hatchery personnel did not examine the individual fish for marks. After this incident, fish in these raceways were counted electronically using the VAKI bioscanners and an estimate of the number of marked fish was generated using a marked-to-unmarked ratio determined during a mark-recapture experiment at pre-release (Table 6).

SIZE ESTIMATION

To maximize ocean survival and maintain the age composition of the population, Peltz and Starkey (1993) recommended that 80% of hatchery coho smolt weigh between 15.1 and 25.0 g, and hatchery chinook salmon weight between 5.1 and 15.0 g at release. At least **36%** and up to 89% of fish reared at EH exceeded this desired weight range (Figures 2 and 3). Fish at EH tend to be larger because EH has an abundance of warm water for rearing during the winter. Although there is less warm water at FRH, more temperature control is available and overall the range of fish sizes comes closer to the recommended levels.

CONCLUSIONS AND RECOMMENDATIONS

1. Continue to follow recommendations from previous reports.
2. Fish to be tagged were collected from the general population in a systematic manner. Fish to be used for mark-recapture experiments were collected by randomly netting fish after crowding. Netting all fish at pre-release is not feasible because they are stressed and ready to migrate. Randomly netting fish can skew the sample toward smaller fish, and a new method for collecting mark-recapture samples still needs to be developed.
3. The Bird Creek and Ship Creek release groups of coho salmon and the Deception Creek release group of chinook salmon at FRH were very close to achieving or did achieve the recommended size range at release. Marine survival rates and the age composition on returning should be at anticipated levels.
4. Coho salmon smolt in the Eklutna Tailrace release group were smaller than the recommended size range, and marine survival rates may be less than optimal.
5. All remaining coho and chinook salmon release groups at FRH, and all release groups at EH contained a greater than optimal percentage of fish that were larger than the recommended size range. Cooler rearing temperatures would help reduce the growth of these fish and increase the percentage of fish that achieve the recommended release size.

Table 6.-Estimated number of marked coho salmon smolt in two rearing units at Fort Richardson Hatchery later released into Ship Creek in 1999.

Statistic	Raceway F3	Raceway F4
<u>At Tagging</u>		
Number marked	33,546	34,610
% of raceway marked"	26.7%	31.6%
<u>Pre-release Sample</u>		
Marked	811	850
Unmarked	2,065	1,930
% marked ^b	28.2%	30.6%
<u>At Release</u>		
Electronic count	93,436	72,354
Estimated number marked fish ^c	26,348	22,123
<u>Mortalities Since Sample</u>		
Marked	91	81
Unmarked	121	109
Adjusted number of marked fish	26,257	22,042
Total fish released	93,224	72,164

^a The percentage of marked fish at the time of tagging is based on the number of fish tagged into the raceway, and the estimated number of fish in the raceway determined by total weight of the fish in the raceway divided by the average weight of one fish.

^b The percentage of marked fish at release is based on a marked-to-unmarked ratio obtained just prior to release.

^c The estimated number of marked fish in the raceway was calculated using the percentage of marked fish in the raceway determined prior to release, and the electronic count of the number of fish in the raceway.

ACKNOWLEDGMENTS

We would like to **thank** Gary Wall and Darrell Keifer for their help and cooperation during coded wire tagging operations at Fort Richardson and Elmendorf hatcheries. We would also like to thank the members of the tagging crews for performing an excellent job at each of the hatcheries.

LITERATURE CITED

- Blankenship, H. L. **1990.** Effects of time and fish size on coded wire tag loss from chinook and coho salmon. American Fisheries Society Symposium **7:237-243.**
- Cochran, W. G. **1977.** Sampling techniques, third edition. John Wiley and Sons, New York.
- Moberly, S. A., R. Miller, K. Crandall, and S. Bates. **1977.** Mark tag manual for salmon. Alaska Department of Fish and Game, Division of Fisheries Rehabilitation, Enhancement and Development, Juneau.
- Peltz, L. and J. Miller. **1990.** Performance of half-length coded wire tags in a pink salmon hatchery marking program. American Fisheries Society Symposium **7:244-252.**
- Peltz, L. and D. Starkey. **1993.** Summary and synthesis of production, marking and release data for coho and chinook salmon smolt released into Upper Cook Inlet, Alaska in **1992.** Alaska Department of Fish and Game, Fishery Data Series No. **93-51,** Anchorage.
- Robson, D. S. and H. A. Regier. **1964.** Sample size in Petersen mark-recapture experiments. Transactions of the American Fisheries Society **93:216-226.**
- Seber, G. A. F. **1982.** The estimation of animal abundance, second edition. Griffin and Company, Ltd., London.
- Sweet, D. and L. Peltz. **1994.** Performance of the chinook salmon enhancement program in Deception Creek, Alaska, **1985-1993.** Alaska Department of Fish and Game, Fishery Manuscript No. **94-3,** Anchorage.

APPENDIX A

Appendix A1.-Historical releases of coho salmon that were marked with adipose finclips and tagged with coded wire tags.

Brood		Release	Total Released		Marked Fish	Tagged Fish	Percent		
			Type of						
Year	Brood stock	Hatchery	Year	CWT Code	Estimate	Estimate ^a	Released	Released	Tagged
Anchorage Urban Streams ^b									
1994	Little Susitna	Ft Richardson	1996	31-25-06	156,050	M-R	46,665	46,058	29.50%
Bird Creek									
1990	Little Susitna	Ft Richardson	1992	31-20-02 31-20-03	95,377	M-R	44,903	37,629	39.50%
1991	Little Susitna	Ft Richardson	1993	31-21-39	140,382	M-R	43,441	42,350	30.20%
1992	Little Susitna	Ft Richardson	1994	31-23-02	84,643	M-R	45,220	44,686	52.80%
1993	Little Susitna	Ft Richardson	1995	31-23-37	154,753	M-R	45,666	45,490	29.40%
1994	Little Susitna	Ft Richardson	1996	31-25-04	147,618	M-R	46,528	45,411	30.80%
1995	Little Susitna	Ft Richardson	1997	31-26-01	146,612	HI	45,901	45,488	31.03%
1995	Little Susitna	Ft Richardson	1997	31-26-27	147,953	HI	45,836	45,469	30.73%
1996	Little Susitna	Ft Richardson	1998	31-26-25	164,211	HI	46,140	46,094	28.07%
1997	Ship Cr (Little Susitna)	Ft Richardson	1999	31-26-15	111,430	EC	37,344	36,746	32.98%
Campbell Creek ^b									
1990	Little Susitna	Ft Richardson	1992	31-20-04 31-20-05	97,076	M-R	43,681	39,444	40.60%
1991	Little Susitna	Ft Richardson	1993	31-21-38	140,797	M-R	43,440	42,916	30.50%
1992	Little Susitna	Ft Richardson	1994	31-23-03	87,686	M-R	44,144	42,963	49.00%
1993	Little Susitna	Ft Richardson	1995	31-23-36	157,241	M-R	45,655	44,995	28.60%
1995	Little Susitna	Ft Richardson	1997	31-25-62	71,519	PC	45,840	45,290	63.33%
1996	Little Susitna	Ft Richardson	1998	31-26-52	83,317	HI	22,453	22,296	26.76%
1997	Ship Cr (Little Susitna)	Ft Richardson	1999	31-01-30	42,046	EC	20,879	20,378	48.47%
Cottonwood Creek									
1990	Fish Creek	Big Lake	1992	31-20-08 31-21-09	53,900	M-R	35,341	32,938	61.10%
1991	Fish Creek	Big Lake	1993	31-21-41	74,198	M-R	43,117	40,875	55.10%
Eklutna Tailrace									
1996	Jim Creek	Ft Richardson	1998	31-26-27 31-26-54 31-26-55 31-26-56	112,219	PC	112,219	111,882	99.70%
1997	Jim Creek	Ft Richardson	1999	31-26-16	126,602	EC	44,073	42,663	33.70%

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Appendix A1.-Page 2 of 2.

Brood		Release			Total Released		Marked	Tagged	Percent
							Fish	Fish	
Year	Brood stock	Hatchery	Year	CWT Code	Estimate	Estimate ^a	Released	Released	Tagged
Fish Creek									
1990	Fish Creek	Big Lake	1992	31-20-12	74,953	M-R	45,538	43,625	58.20%
				31-20-13					
1991	Fish Creek	Big Lake	1993	31-21-40	67,934	M-R	44,050	43,257	63.70%
Homer Spit									
1996	Bear Lake	Elmendorf	1998	31-26-28	130,219	M-R	42,057	41,926	32.20%
1997	Bear Lake	Elmendorf	1999	31-01-40	129,602	M-R	44,405	43,020	33.19%
Little Susitna at Houston									
1990	Little Susitna	Ft Richardson	1992	31-20-07	154,466	M-R	21,884	19,564	12.70%
1991	Little Susitna	Ft Richardson	1993	31-21-37	148,282	M-R	21,404	20,312	13.70%
Nancy Lake									
1990	Little Susitna	Ft Richardson	1992	31-20-06	158,459	M-R	21,598	19,222	12.10%
1991	Little Susitna	Ft Richardson	1993	31-21-37	131,591	M-R	21,001	19,930	15.20%
1992	Little Susitna	Ft Richardson	1994	31-23-01	126,694	M-R	44,489	43,818	34.60%
1993	Little Susitna	Ft Richardson	1995	31-23-39	151,985	M-R	46,261	45,245	29.80%
Ship Creek^b									
1990	Ship Creek	Elmendorf	1992	31-19-63	67,178	PC	44,086	38,443	57.20%
				31-20-01					
1991	Ship Creek	Elmendorf	1993	31-21-36	54,764	PC	42,112	41,322	75.50%
1992	Ship Creek	Elmendorf	1994	31-23-04	75,779	PC	44,031	41,722	55.10%
1993	Little Susitna	Ft Richardson	1995	31-23-38	158,981	M-R	45,491	44,654	28.10%
1995	Little Susitna	Ft Richardson	1997	31-25-63	232,066	PC,HI	45,925	45,741	19.71%
1996	Little Susitna	Ft Richardson	1998	31-26-53	232,765	HI	67,812	66,997	28.78%
				31-26-26					
1997	Ship Ck (L. Susitna)	Ft Richardson	1999	31-26-14	165,388	EC	48,299	45,380	27.44%
				31-01-29					
Wasilla Creek									
1990	Fish Ck	Big Lake	1992	31-20-10	76,315	M-R	44,148	41,985	55.00%
				31-20-11					
1991	Fish Ck	Big Lake	1992	31-21-42	77,174	M-R	43,001	41,711	54.10%
1994	Little Susitna	Ft Richardson	1996	31-25-05	145,923	M-R	46,980	46,839	32.10%

^a M-R is mark-recapture, PC is physical count, HI is hatchery inventory, EC is electronic count.

^b Campbell and Ship creeks were combined and termed "Anchorage Urban Streams" in 1996.

Appendix A2.-Historical releases of chinook salmon that were marked with adipose finclips and tagged with coded wire tags.

Brood		Release	Total Released		Marked	Tagged	Percent			
								Type of	Fish	Fish
Year	Brood stock	Hatchery	Year	CWT Code	Estimate	Estimate ^a	Released			
Buskin River										
1994	Deception Cr	Elmendorf	1995	31-24-31	84,349	M-R	41,572	41,078	48.70%	
1995	Deception Cr	Elmendorf	1996	31-25-09	113,220	M-R	41,259	40,681	35.90%	
Crooked Creek										
1993	Crooked Cr	Elmendorf	1994	31-23-14	224,784	M-R	43,609	43,034	19.10%	
1994	Homer ^b	Elmendorf	1995	31-24-27	184,049	M-R	40,903	38,420	20.90%	
1995	Homer ^b	Elmendorf	1996	31-25-12	193,180	M-R	40,827	40,196	20.80%	
1996	Homer ^b	Elmendorf	1997	31-25-55	223,200	M-R	41,049	39,038	17.49%	
1997	Homer ^b	Elmendorf	1998	31-26-29	137,338	M-R	42,874	42,610	31.03%	
1998	Homer ^b	Elmendorf	1999	31-01-41	193,257	M-R	43,607	42,844	22.17%	
Deception Creek										
1991	Deception Cr	Ft Richardson	1992	31-21-03	179,724	M-R	44,089	33,464	18.60%	
1992	Deception Cr	Ft Richardson	1993	31-21-60	160,194	M-R	42,782	39,420	24.60%	
1993	Deception Cr	Ft Richardson	1994	31-23-17	177,913	M-R	46,289	45,921	25.80%	
1994	Deception Cr	Ft Richardson	1995	31-24-34	184,740	M-R	46,807	46,256	25.00%	
1995	Deception Cr	Ft Richardson	1996	31-25-14	186,918	M-R	47,700	47,145	25.20%	
1996	Deception Cr	Ft Richardson	1997	31-26-03, 04, 05, 06, 07	209,644	PC	209,644	207,973	99.20%	
1997	Deception Cr	Ft Richardson	1998	31-25-32	197,392	PC	197,392	195,615	99.10%	
1998	Deception Cr	Ft Richardson	1999	31-26-17, 18, 19, 20 31-01-31	201,586	PC	201,586	199,722	99.08%	
Eagle River										
1993	Ship Creek	Elmendorf	1994	31-23-13	98,872	M-R	43,612	41,669	42.10%	
Fleming Spit										
1998	Deception Cr	Ft. Richardson	1999	31-26-23	49,773	PC	45,705	45,385	91.18%	
Halibut Cove										
1993	Crooked Creek	Elmendorf	1994	31-23-15	98,872	M-R	21,205	21,038	21.30%	
1994	Ninilchik River	Elmendorf	1995	31-24-30	37,577	M-R	36,944	36,700	97.70%	
1995	Ninilchik River	Elmendorf	1996	31-25-11	97,729	M-R	40,688	39,345	40.30%	
1996	Ninilchik River	Elmendorf	1997	31-25-58	78,133	M-R	40,919	39,487	50.54%	
1997	Ninilchik River	Elmendorf	1998	31-26-32	65,893	M-R	38,476	38,041	57.73%	

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Brood			Release		Total Released		Marked	Tagged	Percent
						Type of	Fish	Fish	
Year	Brood stock	Hatchery	Year	CWT Code	Estimate	Estimate ^a	Released	Released	Tagged
Homer Spit (early run)									
1993	Crooked Creek	Elmendorf	1994	31-23-16	163,963	M-R	26,003	25,615	15.60%
1994	Homer ^b	Elmendorf	1995	31-24-32	216,026	M-R	41,650	40,291	18.70%
1995	Homer ^b	Elmendorf	1996	31-25-07	204,085	M-R	40,868	39,017	19.10%
1996	Homer ^b	Elmendorf	1997	31-25-60	217,773	M-R	41,112	38,810	17.82%
1997	Homer ^b	Elmendorf	1998	31-26-33	177,730	M-R	40,012	39,652	22.31%
1998	Homer ^b	Elmendorf	1999	31-01-45	163,170	M-R	42,561	40,423	24.77%
Homer Spit (late run)									
1992	Kasilof River	Crooked Creek	1994	31-23-19	56,920	M-R	22,612	22,383	39.30%
1994	Homer ^c	Elmendorf	1995	31-24-33	123,048	M-R	41,054	40,466	32.90%
1995	Homer ^c	Elmendorf	1996	31-25-13	108,204	M-R	40,615	38,787	35.80%
1996	Homer ^c	Elmendorf	1997	31-25-61	100,933	M-R	41,028	39,264	38.90%
1997	Homer ^c	Elmendorf	1998	31-26-34	112,100	HI	40,158	39,997	35.68%
Lowell Creek									
1996	Deception Cr	Elmendorf	1997	31-25-59	102,147	M-R	40,906	40,497	39.65%
Ninilchik River									
1991	Ninilchik River	Ft Richardson	1992	31-21-04	132,387	M-R	43,648	41,335	31.20%
1992	Ninilchik River	Ft Richardson	1993	31-21-59	184,585	M-R	44,487	42,960	23.30%
1993	Ninilchik River	Ft Richardson	1994	31-23-18	201,513	M-R	46,193	45,535	22.60%
1994	Ninilchik River	Ft Richardson	1995	31-24-35	54,662	M-R	54,662	54,115	99.00%
1995 ^d	Ninilchik River	Ft Richardson	1996	31-25-15	51,688	PC	51,588	50,866	98.60%
1996 ^d	Ninilchik River	Ft Richardson	1997	31-26-08	50,698	PC	50,698	50,292	99.20%
1997	Ninilchik River	Ft Richardson	1998	31-26-35	48,798	PC	48,798	47,480	97.30%
1998	Ninilchik River	Ft Richardson	1999	31-01-45	49,853	PC	49,853	48,906	98.10%
Seldovia									
1993	Crooked Creek	Elmendorf	1994	31-23-11	107,246	M-R	46,754	45,439	42.40%
1994	Homer ^b	Elmendorf	1995	31-24-29	116,165	M-R	41,609	40,678	35.00%
1995	Ninilchik River	Elmendorf	1996	31-25-10	118,274	M-R	40,667	39,610	33.50%
1996	Ninilchik River	Elmendorf	1997	31-25-57	103,757	M-R	41,279	39,834	38.39%
1997	Ninilchik River	Elmendorf	1998	31-26-31	69,461	M-R	40,654	40,125	57.77%

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Brood		Hatchery	Release Year	CWT Code	Total Released		Marked Fish Released	Tagged Fish Released	Percent Tagged
Year	Brood stock				Estimate	Type of Estimate ^a			
Shakespeare Creek									
1998	Deception Cr	Ft Richardson	1999	31-26-24	49,797	PC	45,023	43,897	88.21%
Ship Creek									
1993	Ship Creek	Elmendorf	1994	31-23-12	199,830	M-R	44,138	42,864	21.50%
1994	Ship Creek	Elmendorf	1995	31-24-28	218,487	M-R	40,764	38,570	17.70%
1995	Ship Creek	Elmendorf	1996	31-25-08	231,444	M-R	41,221	40,109	17.30%
1996	Ship Creek	Elmendorf	1997	31-25-56	326,271	M-R	40,522	40,319	12.36%
1997	Ship Creek	Elmendorf	1998	31-26-30	204,741	M-R	42,073	41,565	20.30%
1998	Ship Creek	Elmendorf	1999	31-01-42	197,168	M-R	44,265	42,262	21.44%
Valdez Glacier Stream									
1998	Deception Cr	Ft Richardson	1999	31-26-22	49,353	PC	46,528	45,923	93.05%

^a M-R is mark-recapture, PC is physical count, HI is hatchery inventory.

^b Homer (Crooked Creek).

^c Homer (Kasilof River).

^d Adjusted for holding mortality before release.